SUMMARIES OF CURRENT NORTH AMERICAN PRE-CAMBRIAN LITERATURE.[1]

TODD[2] maps and gives a general description of the geology of South Dakota. Archean[3] rocks are present in the Black Hills, near Sioux Falls, and near Bigstone Lake in the eastern part of the state.

In the Black Hills the Archean rocks are slates and schists, intruded by granite. The metamorphic effects in the slates and schists become more pronounced as the contact with the granite is approached. Following Van Hise, it is believed that their metamorphism was largely brought about by the intrusion of the granite. The thickness of the slates and schists is from 10,000 to 100,000 feet. In age they are believed to correspond to the Lower Huronian of the Lake Superior region. The granites, while younger than the slates and schists, are still pre Cambrian.

The Sioux quartzite is similar to the quartzite of Baraboo and the Chippewa valley, of Wisconsin, and, following Irving and Van Hise, it is believed to be of Upper Huronian age.

Near Bigstone Lake are exposures of granites, probably of Laurentian age.

All the Archean rocks are overlain unconformably by Cambrian rocks which in general dip away from the Archean exposures.

Keyes[4] gives the result of an examination of the Sioux quartzite. Impressions were seen at several points in the bedding planes of the quartzite which so much resembled those of lamellibranchs of the Cardium and Cytherea types, that, notwithstanding strong pre-conceived notions of the ancient age of the Sioux rocks, faith in their old age was very much shaken. It is concluded that the Sioux formation should be considered as pre-Cambrian until indisputable evidence to

[1] Continued from p. 753, Vol. VI, JOUR. GEOL.

[2] A preliminary report on the geology of South Dakota, by J. E. TODD. South Dakota Geol. Survey, Bull. No. 1, 1895, pp. 172. With map.

[3] Archean is used to designate the pre-Cambrian.

[4] Opinions concerning the age of the Sioux quartzite, by C. R. KEYES. Proc. Iowa Acad. Sci. for 1894, Vol. II, 1895, pp. 218–222.

the contrary is produced, but that there now exist certain doubts concerning the accuracy of this view.

Keyes,[1] in an account of the characteristics of the Ozark Mountains, briefly describes the Archean and Algonkian rocks of the region. Archean rocks occur at the east and west ends of the Ozark uplift. The best known of the areas is the eastern one, the Iron Mountain district of southeastern Missouri. Here the largest areas occur in the vicinity of the peak from which the district takes its name, and other smaller areas are scattered over a considerable range of adjacent territory. The Archean rocks in the Iron Mountain district are granites and porphyries, the latter predominating, both of which are broken through in numerous places by basic intrusives.

At the western end of the Ozark uplift, in Indian Territory, are Archean rocks, principally granites, of which there are many varieties, cut, as in southeastern Missouri, by dikes of basic material.

Immediately overlying the Archean in a number of places are beds of conglomerates and slates provisionally referred to the Algonkian. These appear to best advantage on Pilot Knob.

Haworth[2] describes and maps the pre-Cambrian geology of the area of the Iron Mountain sheet in southeastern Missouri, which covers portions of Iron, St. Francois, and Madison counties. The pre-Cambrian rocks are crystalline, massive, Archean rocks, and crystalline, stratified, Algonkian rocks.

The Archean rocks in general form the uplands. They may be divided into two general classes, basic eruptives and acid eruptives, including granites and porphyries.

The basic eruptives, of remarkably uniform character, occur principally in the southeastern part of the area, usually in dikes cutting through the granites and porphyries, but in a few cases in the form of bosses almost circular in outline. The general trend of the dikes is northeast-southwest.

The granites occur mainly in two large areas, though they are found occasionally in small patches within the porphyries. The two

[1] Characteristics of the Ozark Mountains, by C. R. KEYES. Rept. Missouri Geol. Survey, Vol. VIII, for 1894, pp. 317–352. 1895.

[2] Report on the Iron Mountain sheet — the Archean rocks, by ERASMUS HAWORTH. Rept. Missouri Geol. Survey, Vol. IX, 1896, pp. 15–27. With Sheet No. 3.

areas are the Graniteville and Stout's Creek or St. Francois areas. The porphyries occur in numerous large, uniformly distributed areas, making up nearly half the area of the entire sheet. They include what have been called by other writers quartz-porphyry, feldspar-porphyry, felsite, felsophyre, and orthophyre.

Numerous observations show gradations between the granites and porphyries, and it is concluded that the granite and porphyries were formed from the same or similar magmas, and that their difference in texture is due to crystallization under different conditions.

Algonkian rocks are found near the center of the area, capping the Archean rocks of Pilot Knob. They comprise conglomerates and slates, chiefly the former, and include the iron ore deposits of the locality. The pebbles of the conglomerate are mostly derived from the porphyry. The matrix is a fine felsitic mass mixed intimately with varying amounts of hematite. In places the ore forms almost the entire body of the rocks.

Paleozoic rocks unconformably overlie the crystallines, and dip away from the Archean hills.

Keyes and Haworth[1] describe and map the geology of the Mine Le Mot sheet, which includes portions of Ste. Genevieve, Madison, and St. Francois counties, Missouri. Archean rocks, described by Haworth, occupy about half of the area of the sheet, forming the nucleus about which later formations are exposed in concentric belts. They are granites and porphyries, cut by dikes of diabase. The acid rocks greatly predominate, the granite making up fully nine tenths of the eruptives of the area. The porphyry appears to be the surface facies of the granite, and seems to graduate downward into the latter. This is shown where erosion has been great, and has left high granite hills which are often capped by porphyry.

Cambrian rocks directly overlie the Archean rocks, with unconformable relations.

Keyes,[2] considers the granites and porphyries in the eastern part of the Ozarks. Agreeing with Haworth, he finds the granites

[1] Report on the Mine Le Mot sheet -- General geology, by C. R. KEYES; Archean geology, by C. R. KEYES and E. HAWORTH. Rept. Missouri Geol. Survey, Vol. IX, 1896, pp. 14–44. With Sheet No. 4.

[2] Geographic relations of the granites and porphyries in the eastern part of the Ozarks, by C. R. KEYES. Bull. Geol. Soc. Am., Vol. VII, 1896, pp. 363–376. Pl. 17.

and porphyries to be different facies of the same magma. Further agreeing with Haworth, he finds that the granite occupies the lower ground, the porphyries the higher ground, and that, where there are gradations between the two, the granites are at the base of the hills while the porphyries are at the top, with transition zones between. The granites occupy a comparatively small area in the northeastern part of the district. This is an area of low elevation and near the Mississippi River, and distribution is explained as due to differential erosion. The physiography of the district is discussed, and the conclusion is reached that the crystalline rocks have undergone very considerable erosion since Cambrian time. Agreeing with Van Hise, it is held as probable that the granites and porphyries are of Algonkian age. A deep boring near Kansas City at a depth of 2500 feet penetrated black foliated mica-schist, which has the characteristics of the Archean rocks.

Keyes,[1] in connection with a description of the clay deposits of Missouri by Wheeler, briefly discusses their geological occurrence. Most of the ore-bearing conglomerates of Pilot Knob and vicinity, heretofore called Algonkian, are believed to be Cambrian. The granites and quartz-porphyries of the region are not really of Archean age, as generally considered, but are probably Algonkian. In chemical, mineralogical, and structural characters, and in absence of dynamic effects, they differ from the gneissic and schistose rocks which have been reached in deep drill holes, and, therefore, they are believed to be younger than such gneissic and schistose rocks (which, it may be inferred, are believed to represent the Archean).

The geological conditions of the crystalline rocks are unfavorable to clay deposits.

Comment.— No reasons are given for the belief that the ore-bearing conglomerates of Pilot Knob are Cambrian rather than Algonkian. Until adequate reasons are presented, the conclusion of Haworth, Van Hise, and other workers in the field, that the rocks are Algonkian, must be presumed to be correct.

McConnell[2] reports on an exploration of the Finlay and Omenica

[1] Clay deposits, by H. A. WHEELER — Chapter on the geological occurrence of clays, by C. R. KEYES. Missouri Geol. Survey, Vol. XI, 1896, pp. 36–37.

[2] Report on an exploration of the Finlay and Omenica rivers, by R. G. MCCONNELL. Ann. Rept. Geol. Surv. of Canada, for 1894, Vol. VII, Part C, 1896, pp. 40.

rivers in the Rocky Mountains of western Canada. The Archean[1] rocks of the district consist of a series of well foliated mica-gneisses, mica-schists, hornblende- and actinolite-schists, quartzose schists, and crystalline limestones. The rocks of the series are usually evenly bedded, and conform in dip to the overlying formations. To the series the local term Shuswap is applied.

Shuswap rocks are found on both sides of the Finlay River, from its mouth up to its junction with the Ingenica. North of this point the formation divides. The eastern limb follows the eastern slope of the Finlay valley northwestward to the Quadacha and for some distance beyond. It has a width of four miles at Paul's Branch, where it forms the most westerly range of the Rocky Mountains. This width decreases towards the north and increases to the south. The western limb bends away from the Finlay above the Ingenica, but crosses it again at the great bend which the Finlay describes after leaving the Rocky Mountains, and continues on to the north. The width of this band was not ascertained, as its western boundary was not reached.

Another area of Shuswap rocks, separated from the first by a band of limestones, occurs on the Omenica River above the Oslinca. The band has a width of ten miles.

The Shuswap series is overlain by Lower Paleozoic strata.

Peale[2] maps and describes the geology of the Three Forks quadrangle of Montana. Archean gneisses and Algonkian sediments occupy large areas. The Archean gneisses occur principally in the foothills of the Bridger range, the mountain masses at the northern and southern ends of the Madison range, west of the Madison valley and north of Virginia City, the southern part of the Jefferson range, the foothills of the Gallatin range, south of the Gallatin valley, and beneath the Bozeman Lake beds at the southern end of the plateau, between the Gallatin and Madison valleys. The rocks referred to the Archean may possibly include some that eventually may be referred to the Algonkian. The contacts of the Archean with the overlying sedimentaries are, in all cases, unconformable.

The Algonkian series comprises two divisions, the Cherry Creek beds, and the Belt formation.

[1] In conformity with the usage of Canadian geologists, Archean is above used in the sense of pre-Cambrian.

[2] Geol. Atlas of the United States, Three Forks Folio, No. 24, by A. C. PEALE. Washington, 1896.

The Cherry Creek beds occupy an area of thirty to forty square miles in the foothills immediately west of the Madison River and a few miles north of the southern boundary of the quadrangle, and also a small area on the east side of the Madison valley, at the western edge of the Madison range. The rocks are marbles and interlaminated mica-schists, quartzites, and gneisses. Between Cherry Creek and Wigwam Creek, on the west side of the Madison valley, Cambrian strata rest unconformably upon the upturned edges of the Cherry Creek beds. Before the deposition of the Belt formation, the Cherry Creek beds suffered extensive deformation.

The Belt formation occurs in the northern portion of the district —in the foothills of the northern portion of the Bridger range, in the hills north of the Gallatin and East Gallatin rivers, and in the rugged hills of the Jefferson canyon. In the lower portion of the formation are coarse sandstones and conglomerates, in the central part appear argillites and siliceous limestones, and in the upper part sand stones predominate. The Belt formation is overlain by the Flathead (Cambrian) quartzite. It is possible that further investigation may result in the reference of this formation to the lower part of the Cambrian. At present, however, it is referred provisionally to the Algonkian.

The Flathead and Gallatin formations (Cambrian) rest with marked unconformity upon the Archean for three fourths of the district; for the remainder of the district they rest upon the Algonkian, and the unconformity, if it exists, is very slight.

Weed and Pirsson map[1] and describe the geology of the Castle Mountain mining district of Montana. The Belt group of rocks, assigned to the Algonkian, occupies large areas in the district. The series presents no definite lithological horizons, but there is a general sequence, from the base upward, as follows:

Alternating shales and sandy beds.
Dark gray, laminated, thinly-bedded limestone.
Pearl-gray sericitic shales.
Sandy shales, with thin beds of ripple-marked sandstone.
Red shales and slates.

The series has thus far yielded no fossils. It attains a thickness of 8000 feet. Basic and acid intrusive rocks penetrate the Belt formation very freely.

[1] Geology of the Castle Mountain mining district, Montana, by W. H. WEED and L. V. PIRSSON. Bull. U. S. Geol. Survey, No. 139, 1896, pp. 165. With geol. map.

At many localities the Belt series is seen to be in conformable relations to overlying fossiliferous rocks of Cambrian age, the Flathead and Gallatin formations, and, while assigned to the Algonkian, the series is spoken of as forming the lower part of the Paleozoic of the area.

Comment.— It is unfortunate that rocks assigned to the Algonkian should be spoken of as forming the lower part of the Paleozoic, even though the Belt series may be a downward conformable extension of the Paleozoic. If properly Algonkian, *i. e.*, sedimentaries and equivalent igneous rocks below the Olenellus horizon, whether conformable or not, if referred to any era, they should be referred to the Proterozoic.

Weed and Pirsson[1] briefly describe the geology of the Little Rocky Mountains of central Montana. The core of the mountains is formed of crystalline schists, of which the type most usually seen is a black glistening amphibole-schist, or amphibolite. In the saddle west of Shellrock Mountain, the series consists of amphibole-schists and mica-schists, pink gneiss, and white quartzites, the various rocks occurring in rapidly alternating beds but a few feet thick.

The crystalline schists are overlain by Cambrian sedimentaries. Intruded between the schists and sedimentaries is a great laccolithic body of granite-porphyry.

The presence of the quartzite is taken as indicating the Algonkian age of the crystalline series. However, similar schists occurring in Montana have been generally classed as Archean, and these rocks are metamorphosed and quite unlike the slightly altered Belt Mountain Algonkian series. The crystallines are, therefore, not definitely assigned to either the Archean or Algonkian.

Hague, Weed, and Iddings[2] map and describe the geology of the Yellowstone National Park, Wyoming. Archean rocks are found near the borders of the district in the mountain ranges which encircle the Park plateau. They comprise granites, gneisses, and schists. The granites and gneisses are for the most part coarsely crystalline, and the entire series shows the effect of metamorphism by pressure.

Algonkian rocks are recognized only in the southern end of the

[1] The geology of the Little Rocky Mountains, by W. H. WEED and L. V. PIRSSON. JOUR. GEOL., Vol. IV, 1896, pp. 399–428.

[2] Geol. Atlas of the United States, Yellowstone National Park Folio, No. 30, by ARNOLD HAGUE, W. H. WEED, and J. P. IDDINGS. Washington, 1896.

Park, and are best exposed on the southern slope of Mount Sheridan, from which the formation has been called the Sheridan quartzite. The Sheridan quartzite formation comprises sandstones and slates, which contain no fossils. Unconformably overlying the Sheridan quartzite is the Ellis (Juratrias) limestone. The assignment of the formation to the Algonkian is based largely on the fact that similar rocks are unknown in the Paleozoic series, and on the fact that no sedimentary rocks older than these quartzites are exposed in this district.

Hague,[1] in a discussion of the age of the igneous rocks of the Yellowstone National Park, mentions the occurrence of rocks of Archean age in the surrounding mountain ranges. The Tetons, bordering the park to the south, consist mainly of an Archean mass, which towers high above all later rock formations. In the Absaroka range, stretching along the entire east side of the park, and formed mainly of igneous rocks, granite and schists are exposed at the northern end. The Snowy range, which shuts in the park to the north, is largely made up of Archean schists, gneisses, and granites, associated with the more recent outbursts of lava. In the Gallatin range, on the west, a body of crumpled gneisses and schists forms the nucleus of the mass. The Archean masses formed either a part of a broad continental mass, or a group of closely related islands. Resting unconformably upon the Archean are great thicknesses of Paleozoic and Mesozoic rocks.

Eldridge[2] gives an account of a geological reconnaissance across Idaho, on a northeast line through Boisé and Salmon City. Rocks are found which are provisionally referred to the Archean and Algonkian. To the Archean are referred granite and gneiss, which have their greatest development in the mountains of the western part of the state, but which are also widely exposed elsewhere. In places in the granite and gneiss are included bands of calcareo-micaceous or quartzitic slates, and in these cases the reference of the rocks to the Archean, instead of the Algonkian, is questionable. To the Algonkian is provisionally assigned the great series of micaceous, quartzitic, and chloritic schists of eastern Idaho. The reference is based merely upon

[1] The age of the igneous rocks of the Yellowstone National Park, by ARNOLD HAGUE. Am. Jour. Sci., 4th ser., Vol. I, pp. 445–457, 1896.

[2] A geological reconnaissance across Idaho, by GEORGE H. ELDRIDGE. Sixteenth Ann. Rept. U. S. Geol. Surv., Part II, 1895, pp. 217–276.

lithological character, and the resemblance to other beds in the Cordilleras which have already been so assigned. The Algonkian series in areas of strong development has a probable thickness of 3000 to 4000 feet. It is believed to be unconformable with the underlying granite.

Cross[1] describes the geology of the Cripple Creek district of Colorado. The account of the general geology is substantially the same as that previously given by Cross for the Pike's Peak quadrangle,[2] of which the Cripple Creek district is a part. Granites and gneisses occupy a large area in the district. Included in these granites and gneisses are large and small fragments of quartzite, quartz-fibrolite-schist, quartz-mica-schist, and other similar rocks. It is believed that the quartzite fragments belong to a great series of pre-Cambrian (Algonkian) sediments. Hence the granites including such fragments are not Archean; but they are older than the only Cambrian rocks as yet identified in Colorado, and they are therefore mapped as Algonkian. The schists are probably also sedimentary, but it is quite possible that some, if not all, have been produced from Archean gneisses forming the foundation upon which the Algonkian sediments were laid down.

Emmons, Cross, and Eldridge[3] describe and map the geology of the Denver basin in Colorado. Pre-Cambrian rocks form the mass of the Colorado or Front Range along the western border of the Denver Basin, later formations resting against the flanks of the mountains. In the lower canyons of South Boulder and Coal creeks, are beds of highly altered quartzite and conglomerate, associated with schists, aggregating a thickness of 1000 feet, which occupy a position between Triassic sandstones and the gneisses of the interior of the range. These are undoubtedly sedimentary and are probably of Algonkian age. In passing from these sedimentaries westward toward the center of the range there appear successively gneisses, granite-gneisses, and massive granite. As the areas occupied by the granites and sedimentaries have not been definitely delimited, and as the sedimentaries

[1] General geology of the Cripple Creek district, Col., by WHITMAN CROSS. Sixteenth Ann. Rept. U. S. Geol. Surv., Part II, 1895, pp. 13–109.

[2] Reviewed in this JOURNAL, Vol. IV, 1896, p. 371.

[3] Geology of the Denver Basin in Colorado, by S. F. EMMONS, WHITMAN CROSS, and G. H. ELDRIDGE. Mon. U. S. Geol. Surv., No. XXVII, 1896, pp. 556. With maps.

occupy but a small proportion of the pre-Cambrian area, the sedimentaries are not mapped as Algonkian, but, with the granites, are mapped as pre-Cambrian.

Osann[1] gives the geology and petrography of the Apache (Davis) mountains of western Texas. The oldest rocks found therein are the crystalline schists, which composed the greater part of Carrizo and Van Horn mountains. Here is found a great set of coarsely crystalline gneiss, mica-schist, and associated schistose rocks. These have in general a parallel northwest-southeast strike, which agrees with the axis of the range. Following Professor von Streeruwitz, these are placed with the fundamental rocks.

Sapper[2] describes the geology of Chiapas, Tabasco, and the Peninsula of Yucatan, and mentions the occurrence of Azoic rocks in the Sierra Madre Mountains. These rocks include gneiss, mica-slates, and phyllites. A band in the first northern range of the Sierra, near the plantations of Piedad and San Vincente, trends N. 7° W., and dips 5° to the N.E. Among the bowlders washed down by the Aguacate River may be seen gneiss, mica-slates, and phyllites, which indicate the presence of the crystalline formations also in the interior of the Sierra Madre.

Comment.—The term Azoic is used in a very indefinite way. It apparently is applied to all ancient crystallines, both sedimentary and igneous, and is not necessarily confined to the pre-Cambrian. However, the term is placed as a subheading under sedimentary formations, indicating, possibly, that ancient sedimentaries only are included.

Ells[3] reports on the geology of a portion of the Province of Quebec comprised in the southwest sheet of the eastern townships map (Montreal sheet), and describes pre-Cambrian rocks occurring to the east of the St. Lawrence River. These occur along the axis of the Sutton

[1] Beiträge zur Geologie und Petrographie der Apache (Davis) Mts., West-Texas, by A. OSANN. Min. und Pet. Mitt., Bd. XV, Heft 5, 6, 1896, pp. 394–456, mit Tafeln XI–XII, Fig. im Texte.

[2] Geology of Chiapas, Tabasco, and the Peninsula of Yucatan, by C. SAPPER. JOUR. GEOL., Vol. IV, pp. 938–947, 1896.

[3] Report on a portion of the Province of Quebec, comprised in the southwest sheet of the "Eastern Townships" map (Montreal sheet), by R. W. ELLS. Ann. Rept. Geol. Surv. of Canada, for 1894, Vol. VII, Part J, 1896, pp. 1–92.

Mountain range, and in the anticline east of Memphremagog Lake near Fitch Bay.

The crystalline schists of the Sutton Mountain range may be divided into two principal portions, viz., the gneissic, micaceous, quartzose, and talcose schists of the central portion or that in which the axis of the anticline is situated, and a series of green, chloritic, schistose rocks, with the characters of altered dioritic rocks, constituting an easily separable portion, flanking the central area of schists to the west, and extending from the Vermont boundary to the St. Francis in the vicinity of Richmond. This second or chloritic division is recognized also at various points on the eastern slope of the range, but it does not there present so marked a development. The age of the green schistose, dioritic portion is doubtful, but it appears to coincide to some extent with the Volcanic Group of Selwyn,[1] which he supposed to be probably Lower Cambrian or Huronian.

East of Memphremagog Lake, near Fitch Bay, the pre-Cambrian rocks are schistose, altered, dioritic rocks, occasionally with micaceous bands, and often containing clear grains of quartz. These rocks are apparently allied to the green chloritic schists of the west slope of the Sutton Mountain range, and are placed on the map as doubtfully Huronian.

Cutting the pre-Cambrian rocks, and possibly also later sediments, are a considerable variety of rocks, such as granites, syenites, diorites, diabases, serpentines, traps, etc., evidently of different ages. It is probable that the age of the granites is not far from the close of the Silurian period.

Adams[2] describes and maps the Laurentian area north of the St. Lawrence River, in the northwest corner of the southwest sheet of the "Eastern Township" map (Montreal sheet). This Laurentian area is a portion of the southern margin of the great northern Canadian area of Laurentian rocks. The area is about equally divided between the rocks of the Laurentian system and intrusions of anorthosite which break through them. The Laurentian[3] consists of red and gray ortho-

[1] Stratigraphy of the Quebec Group and the older crystalline rocks of Canada, by A. R. C. SELWYN. Rept. Geol. Surv. of Can., for 1877–8, Part A, p. 3.

[2] Laurentian area in the northwest corner of the Montreal sheet, by F. D. ADAMS. Supplementary chapter to Ell's report on a portion of the Province of Quebec. Ann. Rept. Geol. Surv. of Canada for 1894, Vol. VII, Part J, 1896, pp. 93–112.

[3] The term Laurentian is thus used as it was by Logan.

clase gneisses, presenting great variations both in structure and composition, with which are associated crystalline limestones, quartzites, and amphibolites. In certain parts of the area two divisions can be recognized in the Laurentian: an upper series, characterized by the presence of crystalline limestones, quartzites, and gneisses of sedimentary origin with a banded structure, called the Grenville series; and a lower series of gneisses in which no limestone, etc., occur, and which possess a foliated rather than a banded structure, known as the Fundamental Gneiss. Grenville rocks are recognized south of Rawdon and in the westerly portion of the St. Sauveur district. The Fundamental Gneiss apparently occupies much of the St. Jerome district. However, it has been found impossible to separate the two series and delimit them on the map.

The composition of most, if not all, of the gneisses belonging to the Fundamental Gneiss can be paralleled among the igneous rocks, and it is concluded that many of these gneisses, at least, were of igneous, probably of intrusive, origin. In the Grenville also some of the gneisses are of igneous origin. However, many are believed to be of sedimentary origin, for the following reasons: (1) they are associated with numerous and heavy beds of limestones and quartzite; (2) they have a prevailing banded character, accompanied by a very extensive recrystallization; (3) graphite is of frequent occurrence in them; (4) chemical analyses show that they have the composition, not of igneous rocks, but of sedimentary sands and muds.

The quartzite is sometimes pure, but frequently holds garnet, sillimanite, or other minerals. The limestones are coarsely crystalline marbles, sometimes pure, but at other times including grains of quartz, pyroxene, phlogopite, graphite, and other minerals.

The anorthosite belongs to the gabbros, but is characterized by the great preponderance of plagioclase feldspar, which is often so abundant as to make up the entire rock. At its contact with the gneisses are many contact phases. The anorthosite has been squeezed and foliated, together with the gneisses which it cuts, and it is concluded that its intrusion antedated at least the termination of the great earth movements which affected the Laurentian in pre-Potsdam times. In proportion as the anorthosites exhibit granulation they become light colored, some of the most metamorphosed ones resembling marble in appearance, although chemically they do not differ from the less modified anorthosites.

On the upturned edges of the Archean rocks, both gneiss and anorthosite, the Potsdam sandstone and other Cambro-Silurian rocks repose in flat and undisturbed beds.

Ells and Barlow[1] describe the physical features and geology of the proposed Ottawa Canal between the St. Lawrence River and Lake Huron. The proposed canal for several hundred miles traverses for the most part Archean rocks nearly at right angles to the strike of their schistosity or banding. The work of Logan, Murray, Lawson, and Adams, and others of the important workers on the Canadian crystalline is briefly summarized.

The Grenville series of the Original Laurentian area probably illustrates the most perfect section of Laurentian rocks which we can yet recognize. This section shows various kinds of gneisses, foliated and stratified, with foliated and massive granites and syenites, pyroxenic, dioritic, hornblendic, and quartzose rocks, and quartzite and limestone. In the basal beds of the limestone and quartzite, supposed to constitute the upper member of the series, are interstratified bands of rusty quartzose gneiss, which from the available evidence is believed to form an integral part of the limestone series. This portion presents in its banded arrangement of quartzose and calcareous rocks, the usual aspect of true altered sedimentary strata. The same well banded arrangement is also visible in some of the directly underlying gneiss; but in the case of the great mass of this gneiss, the microscopic examination shows the evidence of an aqueous origin to be wanting. Some portions of the igneous rocks are undoubtedly older than the limestones, and most probably represent the lowest portions of the earth's crust known to us. Other portions are clearly established to be of more recent age than the crystalline limestone. The oldest gneisses are foliated, rather than stratified, but in their foliation they underlie the regular series of stratified hornblende and other gneisses which occur frequently between the fundamental gneiss and the crystalline limestone and quartzite series at the summit of the section. To this fundamental series may be assigned the rocks of Trembling Mountain, those forming the anticlinals north of Lachute, rocks from various places throughout the Grenville district, and large areas at

[1] The physical features and geology of the route of the proposed Ottawa Canal between the St. Lawrence River and Lake Huron, by R. W. Ells and A. E. Barlow. Proc. and Trans. Roy. Soc. of Canada, 2d ser., Vol. I, Sec. IV, 1895, pp. 163–190. With sketch map.

different places along the Upper Ottawa River section. Concerning many of the intermediate gneisses, it may be said that while in their general aspect they resemble stratified sedimentary rocks, their study under the microscope shows them to have presumably a different origin, so that it is possible that the true altered aqueous portion may be confined to the areas of crystalline limestone with their associated bands of quartzite and grayish quartzose and hornblende gneiss. The crystalline limestones are particularly developed along the Ottawa River section, from the vicinity of Deschenes Lake, west of Ottawa city, to the village of Bryson, in which section they are frequently cut by large areas of granitic and dioritic rocks. At one place, near the Chats, the limestone is overlain by a considerable breadth of Huronian-looking schists, etc., which have been described under the name of Hastings series. The limestone has its most westerly outcrop on the Ottawa in the vicinity of Coulonge Lake, a short distance west of the Black River. From here west to the mouth of the Mattawa the limestone occurs as separate belts occupying synclinals in the upper stratified gneisses.

The rocks along the route of the Mattawa and French Rivers to Lake Huron are chiefly those which have been regarded as Laurentian gneisses. There is very little of the crystalline limestone which forms such an abundant constituent of the Laurentian farther east, and this, as well as the apparent inferior position of the gneisses, according to their banding, caused them early to be placed at the very base of the geological series, and called the Lower Laurentian series. Crystalline limestone occurs at Talon Lake, on the east shore of the Great Manitou or Newman Island in the eastern part of Lake Nipissing, as well as on two of the small islands composing this group, and on Iron Island. All the evidence seems to point to the fact that the limestone has been caught up in the gneisses during its eruption.

The foliation of the gneisses is produced either by (1) alternation of light and dark bands, or (2) by the more or less parallel distribution of the component minerals. In many of the plutonic rocks, and particularly in the granites and similar rocks, there is a marked tendency for the bisilicates to aggregate themselves in certain belts or patches (called Auscheidungen in the granites). The result of pressure on a rock characterized by the presence of these masses would be the flattening of the dark areas into more or less lenticular areas. Again, many of the dark bands are seen to have had their

origin as dikes, which have been intruded along the planes of foliation.

Smyth[1] describes pre-Cambrian diabase dikes cutting the granites and gneisses of the Admiralty Group of the Thousand Islands, St. Lawrence River.

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[1] A group of diabase dikes among the Thousand Islands, St. Lawrence River, by C. H. SMYTH. Trans. N. Y. Acad. Sci., Vol. XXIII, 1893–4, pp. 209–214.